THE PALYNOLOGY OF THE AALENIAN (MIDDLE JURASSIC) SEDIMENTS OF JACKDAW QUARRY, GLOUCESTERSHIRE, ENGLAND

by

J. B. Riding

Summary

The palynology of fifteen samples from the Naunton Clay, Harford Sands, Snowshill Clay and Tilestone of Jackdaw Quarry, Gloucestershire is outlined. Previous research is reviewed, concentrating particularly on the position of this sequence with respect to the standard ammonite zonation.

Palynological evidence for a minor marine transgression and subsequent regression in the Snowshill Clay is outlined and the biostratigraphic value of the dinoflagellate cysts *Nannoceratopsis ambonis* Drugg 1978 and *N. triceras* Drugg 1978 discussed. Selected taxa are illustrated and full species lists given.

Introduction

Jackdaw Quarry, Stanway Hill, Gloucestershire is an important exposure of rocks of the Aalenian Stage in the southern Midlands. It is the only continuous section described through the Naunton Clay, Harford Sands, Snowshill Clay and Tilestone. Samples from these units generally yielded well-preserved assemblages of palynomorphs.

Palynological techniques have proved invaluable in age-dating and correlation studies, particularly offshore. As a consequence of discoveries of hydrocarbons in the Mesozoic sediments of the north-west European continental shelf there has been a significant upsurge in Mesozoic palynology, yet few detailed records of Aalenian palynomorphs are available. The majority of publications on this topic are concerned with miospores, e.g. Couper (1958). A notable exception is Davey (in Penn *et al.*, 1980), who outlined the distribution of Aalenian and Bajocian microplankton from a borehole in Lyme Bay, Dorset.

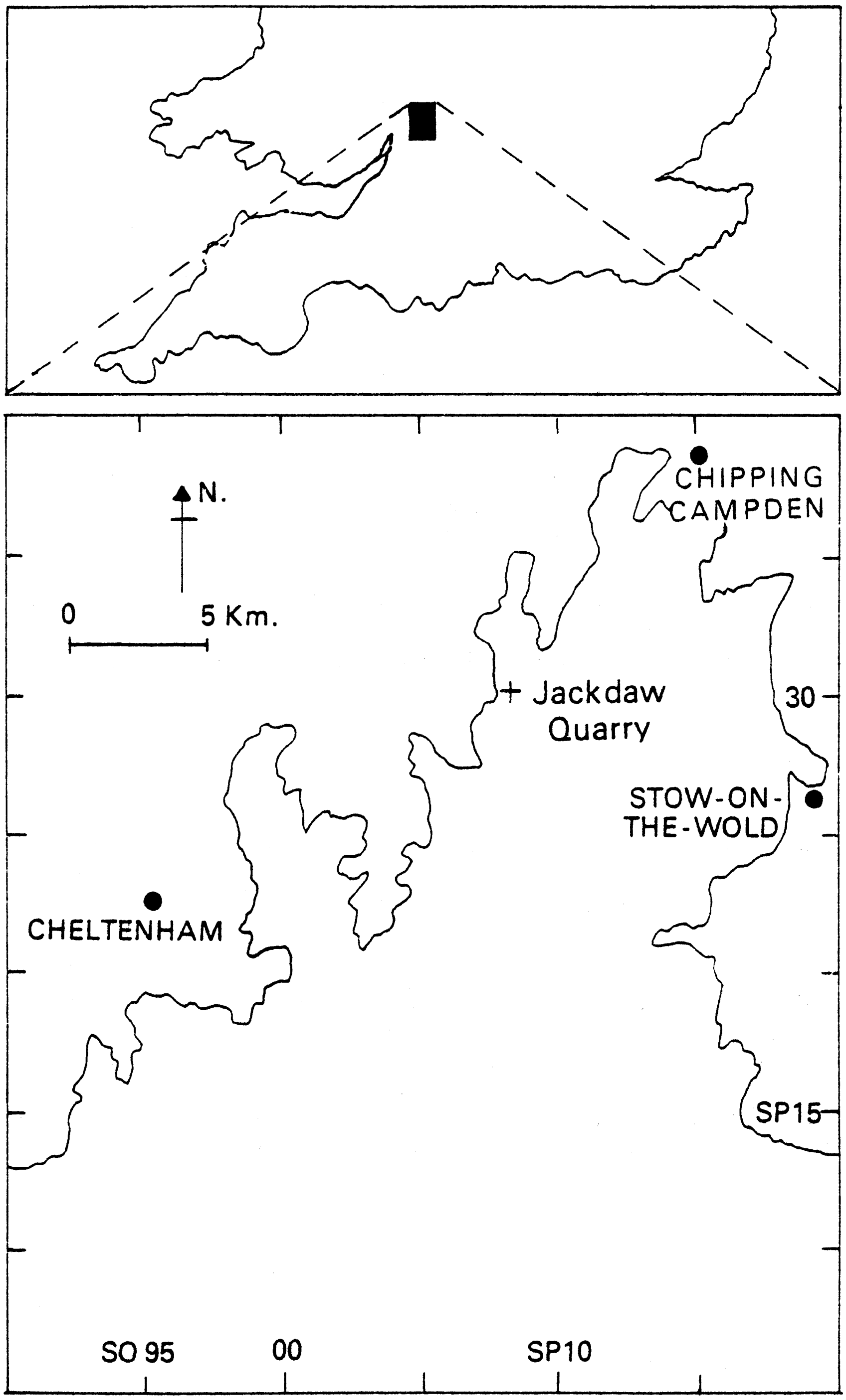
The Jackdaw Quarry; location and sample details

The location of Jackdaw Quarry (SP 078310) is shown in text-figure 1. The section present in the upper level of the quarry (above the Upper Freestone and below the Lower Trigonia Grit) is shown in text-figure 2. A full description of the quarry section was given by Parsons (1976), who recognised eighteen lithological units. The relative positions of the samples utilised are indicated in text-figure 2, which also shows the position of units three to fourteen of Parsons (*op. cit.*).

Geological background

The Naunton Clay, Harford Sands, Snowshill Clay and Tilestone (or Concava Beds of Arkell, 1933) are a series of thin sands, clays and limestones which show marked lateral variations in thickness and lithology. Together with the underlying (dominantly oolitic) limestone units, Scissum Beds, Yellow Guiting Stone, White Guiting Stone and Upper Freestone they make up the Lower Inferior Oolite in the north Cotswolds. The Naunton Clay—Tilestone sequence is confined to the north Cotswolds, occurring on the eastern limb of the Cleeve Hill Syncline between Cheltenham and Chipping Campden. The full extent of the original area of deposition is not clear because of folding and erosion.

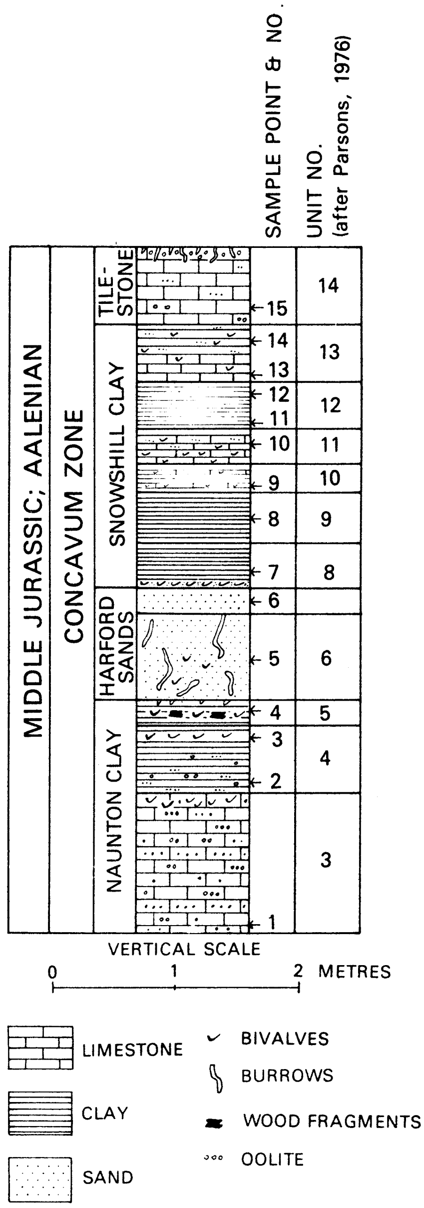
The lithologies exhibited by the Naunton Clay—Tilestone sequence are atypical of the Lower Inferior Oolite of the Cotswolds, which consists dominantly of pure oolitic limestones. According to Parsons (1976) the



Text-fig. 1 Location of Jackdaw Quarry. The solid line indicates the position of the Inferior Oolite scarp.

beds were deposited with an overlap from the north and were overstepped from the south by the Trigonia Grit (Middle Inferior Oolite).

The environment of deposition of the quarry sequence has been interpreted, on the basis of sedimentological and palaeontological evidence (Parsons, *op. cit.*), as a shallow-water, marginally marine coastal plain. The occurrence of deep-burrowing bivalves and intense bioturbation (Mudge, 1978) suggest that the Harford Sands represent intertidal conditions. The presence of plant impressions and rare, thin, impersisent lignite layers in the Naunton Clay suggests that the area of deposition was close to a richly-vegetated shoreline.



Text-fig. 2 The Naunton Clay-Tilestone sequence at Jackdaw Quarry. Units 3-14 of Parsons (1976) and the positions of the samples are indicated.

Development of the lithostratigraphical nomenclature

The Naunton Clay was named by Richardson (1929) and the Harford Sands, Snowshill Clay and Tilestone by Buckman (in 1888, 1897 and 1901 respectively). Cave and Penn (1972) suggested that the Naunton Clay—Tilestone sequence should be included in the Middle Inferior Oolite, but Parsons (1976) rejected this proposal. Cave and Penn's interpretations suggest that the Upper Freestone/Naunton Clay junction is unconformable. Parsons (*op. cit.*) pointed out that at Jackdaw Quarry this junction is gradational and demonstrated that the Tilestone/Lower Trigonia Grit boundary is unconformable. Hence Parsons (*op. cit.*) retains the Naunton Clay—Tilestone sequence in the Lower Inferior Oolite.

Mudge (1978) stated that, in his view the Naunton Clay—Tilestone sequence is partly equivalent to the underlying Upper Freestone and overlying Lower Trigonia Grit. He proposed that the entire sequence should be called the Harford Sands Member (of his Lower Inferior Oolite Formation), the type section being Harford Railway Cutting [SP 134218]. However, Cope *et al.* (1980) rejected this proposal because it would have altered a long-established stratigraphical nomenclature, thereby contravening the recommendations of Holland *et al.* (1978).

Ammonite biostratigraphy

There is no direct evidence that the *Graphoceras concavum* Zone is represented in the north Cotswolds. Buckman (1910) recorded a specimen of '*Graphoceras*' sp. from the 'Snowshill Clay' of Stanway Hill, but Parsons (1976) demonstrated that it came from the Lower Trigonia Grit.

Parsons (*op. cit.*) identified an ammonite from the Tilestone of the Harford railway cutting (housed in the Oxford University Museum) as *Graphoceras* cf. *apertum* (Buckman), a form found in both the *G. concavum* and *Hyperlioceras discites* zones.

STAGE	AMMONITE ZONE	SEQUENCE IN NORTH COTSWOLDS
BAJOCIAN (PARS)	*H. discites*	LOWER TRIGONIA GRIT *
AALENIAN (PARS)	*G. concavum*	TILESTONE
		SNOWSHILL CLAY
		HARFORD SANDS
		NAUNTON CLAY
	L. murchisonae (pars)	UPPER FREESTONE *
		WHITE GUITING LST. (PARS)

Text-fig. 3 Adapted from Cope *et al.* 1980, this diagram shows the position of the Naunton Clay-Tilestone sequence with respect to the standard ammonite zonation.

Asterisks indicate positive ammonite evidence for the unit's age (vertical ruling indicates non-sequence).

Ammonite data has proved that the Lower Trigonia Grit is of *H. discites* Zone age (Parsons, *op. cit.*) and that the Upper Freestone lies within the *Ludwigia murchisonae* Zone (Mudge, 1978), (see text-figure 3).

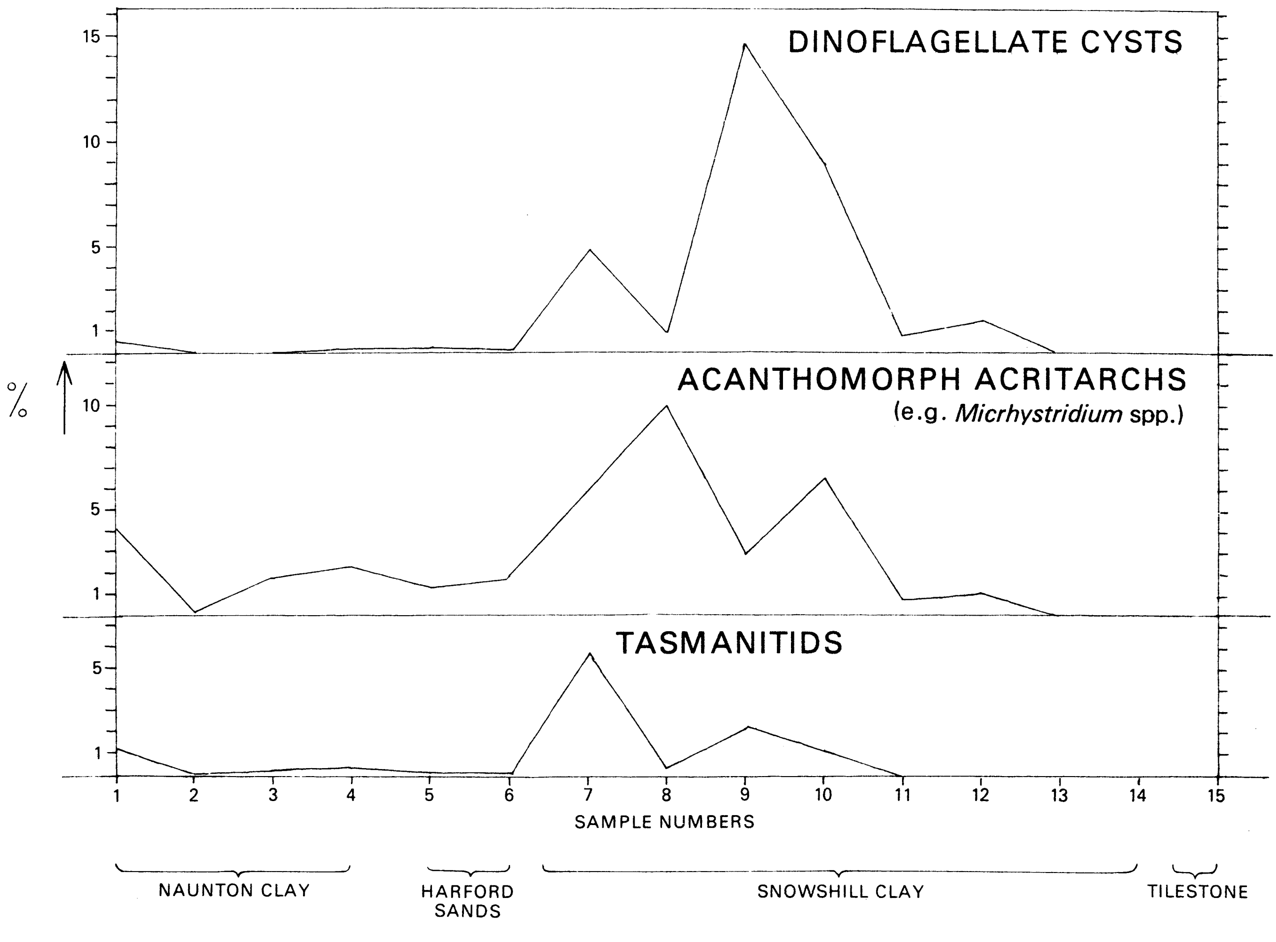
Text-figure 3, adapted from Cope *et al.* (1980) summarises the ammonite evidence, which suggests that much of the Naunton Clay—Tilestone sequence is of *G. concavum* Zone age.

Preparation and the nature of the palynomorph assemblages

Standard preparation techniques were used to extract the palynomorphs. The samples from the Naunton Clay, Harford Sands, Snowshill Clay and Tilestone generally yielded abundant, well-preserved palynomorphs. The underlying White Guiting Stone and Upper Freestone were sampled, but proved barren of palynomorphs. Limestone samples, particularly from outcrop, often yield very poor palynomorph assemblages due to oxidation of organic matter during deposition, diagenesis and weathering.

All of the residues recovered were dominated by terrestrially-derived material, i.e. spores, pollen and woody tissue. Marine palynomorphs (dinoflagellate cysts, acritarchs and tasmanitids) were consistently present but numerically subordinate to terrestrial elements.

Palynology has been used with great effect in palaeoecology. The relative proportions of terrestrially-derived and indigenous marine palynomorphs have proved a reliable guide to relative distance from shoreline or the degree of marine influence. Text-figure 4 shows the relative proportions of dinoflagellate cysts, acanthomorph acritarchs (spiny spheres of presumed algal origin) and tasmanitids (the remains of presumed green algae) in the samples studied from the Naunton Clay—Tilestone sequence. A clear increase in marine influence upwards through the sequence is shown by text-figure 4, the lower portion of the Snowshill Clay having many more indigenous marine palynomorphs than the rest of the succession.



Text-fig. 4 The abundance of the three major groups of marine palynomorphs within the interval considered expressed as a percentage of the total assemblage (miospores and microplankton).

All of the samples can be considered to indicate marginal marine conditions, although it appears a minor marine transgression occurred during early Snowshill Clay times. It is evident from text-figure 4 that the three marine palynomorph groups 'peak' at different times; the tasmanitids are the first group to reach their acme and the first to decline, followed by acanthomorph acritarchs and then by dinoflagellate cysts. This pattern suggests that the different groups reacted sequentially to the minor marine transgression postulated for the lower Snowshill Clay.

Wall (1965) when discussing the palaeoecology of the British Lower Jurassic found that acanthomorph acritarchs e.g. *Micrhystridium* Deflandre 1937 preferred a partly enclosed, inshore environment whereas polygonomorph (polygonal, spiny forms) and netromorph acritarchs (elongate/fusiform spiny bodies) seem to characterise offshore, open-marine palaeoenvironments. He postulated that acritarch assemblages dominated by a single species represent inshore conditions, while diverse assemblages indicate open-sea situations. He also suggested that long-spined acanthomorph acritarchs preferred quiet, low-energy conditions and that forms with short spines characterised high-energy, turbulent environments. The Naunton Clay, Harford Sands and Snowshill Clay all yield good assemblages of the acanthomorph acritarch genus *Micrhystridium* (see text-figure 4). The relatively long-spined species *Micrhystridium fragile* Deflandre 1947 consistently dominates these assemblages and hence a placid, inshore marine environment is inferred.

The only dinoflagellate cyst genera encountered were *Nannoceratopsis* Deflandre 1938 (four species recorded, in fairly large numbers, particularly in the Snowshill Clay) and very rarely, *Sentusidinium* Sarjeant & Stover 1978 (one form recorded, very rarely). Due to its presence in marginal marine (and even estuarine sediments) *Nannoceratopsis* is considered to have been euryhaline. In situations where species of *Nannoceratopsis* dominate the dinoflagellate cyst assemblages, marginal conditions are suggested.

The evidence from the acritarchs and dinoflagellate cysts agrees with the quiet, low-energy nearshore environment postulated by Parsons (1976) and Mudge (1978). Tasmanitids, the presumed cysts of unicellular green algae belonging to the Prasinophyceae typify subsaline marine conditions. They appear to characterise brackish water or shallow water (often restricted) marine environments, where the salinity has been reduced due to freshwater runoff.

Miospores overwhelmingly dominate the assemblages, consituting, on average, 85% of the palynomorph assemblages. Gymnospermous pollen accounts for 75% of the miospores and pteridophyte spores for the remainder. The relative abundance and diversity of pteridophyte spores (17 genera, 29 species) indicate the proximity of a land area with an abundant and varied pteridophyte flora. Species of the gymnospermous pollen genus *Spheripollenites* Couper 1958 are by far the commonest components in the samples studied, often reaching 30% of the total palynomorph assemblage.

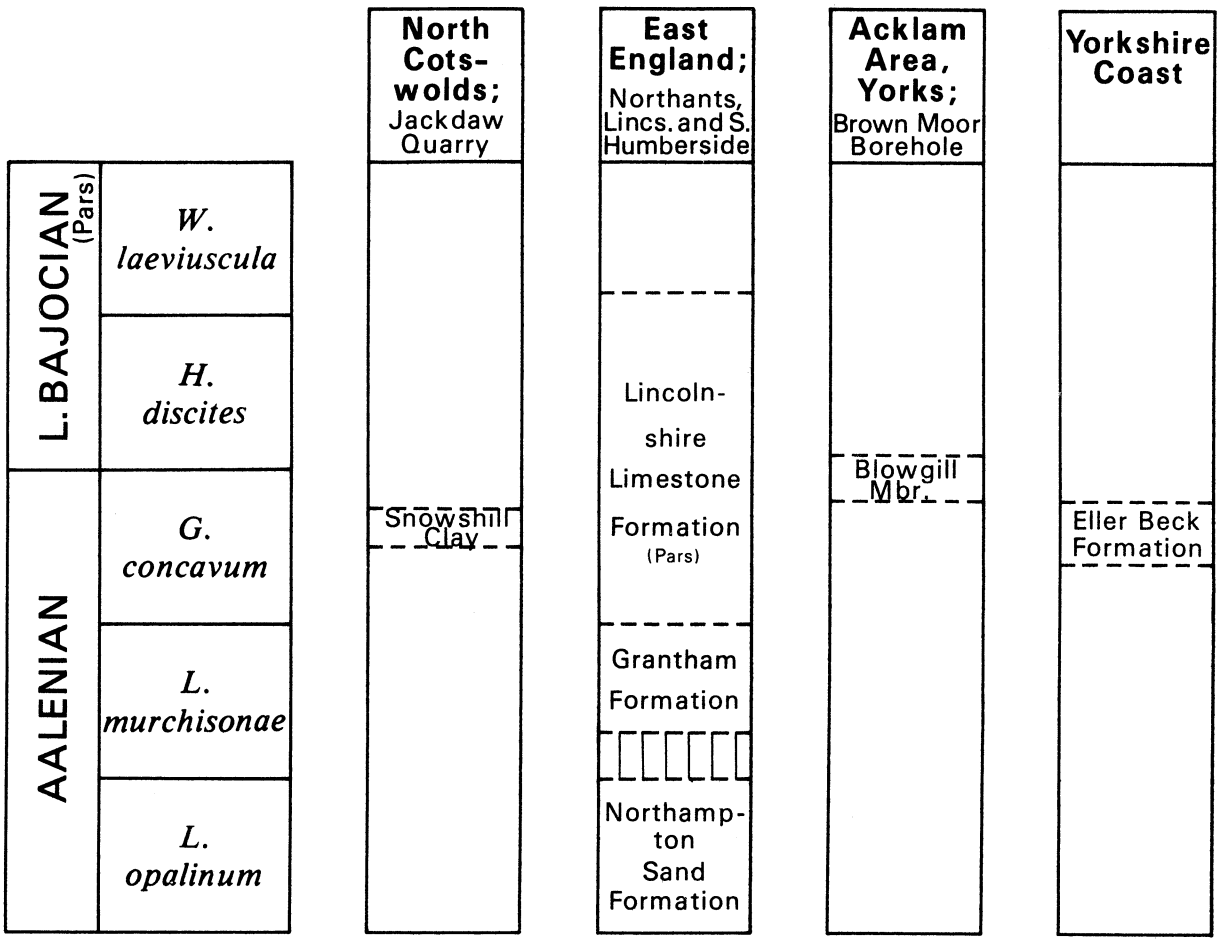
Stratigraphic Palynology

The miospore taxa present are relatively long-ranging forms and it is not surprising that there are no significant changes in the floras throughout the section. The miospore assemblages accord well with other European Aalenian/Bajocian records (Couper, 1958; Tralau, 1968; Guy, 1971). The acritarchs and tasmanitids are also relatively long-ranging and appear to be of little use stratigraphically.

In contrast, dinoflagellate cysts are used extensively for age-determination and correlation in the Jurassic. The ranges of *Nannoceratopsis gracilis* and *N. spiculata* are well estabished (Thusu, 1978; Sarjeant, 1979), both species occurring from the late Pliensbachian to the Bathonian. *Nannoceratopsis ambonis* Drugg 1978 however, appears to be more restricted stratigraphically, being confined to the Snowshill Clay (samples 7-10 of text-figure 2) in the Jackdaw Quarry sequence. The author has recorded *N. ambonis* from the Northampton Sand Formation, Grantham Formation and from the Lincolnshire Limestone Formation, all in eastern England, and from the Blowgill Member (Cloughton Formation) of Brown Moor Borehole in North Yorkshire (Gaunt *et al.*, 1980). It is also present in the Eller Beck Formation of North Yorkshire (R. Woollam, pers. comm.). These occurrences are summarised in text-figure 5. In terms of abundance *N. ambonis* is commonest in the *Graphoceras concavum* ammonite Zone, and appears to be confined to the Aalenian and early Bajocian. The type material is from the German Aalenian (Drugg, 1978). *N. ambonis* was figured by Fenton and Fisher (1978, as *Nannoceratopsis* sp. 1) who gave a breakdown of its stratigraphic distribution in north-western Europe (data which accord with the information in text-figure 5), and reported the species from the Aalenian of Greenland and Arctic Canada.

Also of value biostratigraphically is *Nannoceratopsis triceras* Drugg 1972 which in the Jackdaw Quarry section was found rarely in sample 10 (Snowshill Clay, Unit 11, see text-figure 2). The author has however, recorded this species from the *Dactylioceras tenuicostatum* Zone (early Toarcian) to the *Hyperlioceras discites*/*Witchellia laeviuscula* zones (Bajocian) of eastern England. The observation by Drugg (*op. cit.*) that this form is very rare throughout this interval, yet consistently present is concurred with here. It is reported from the Late Pliensbachian of north-western Europe as Dinoflagellate sp. 1 by Morbey and Dunay (1978) and as "*Paranannoceratopsis triadis*" (informal name) by Morbey (1978). Wille and Gocht (1979) describe *Nannoceratopsis tricornuta*, which is a junior synonym of *N. triceras* from the Lower Toarcian (Lias epsilon) of south-western Germany. The holotype is described from the German Aalenian,(*Leioceras opalinum* Zone), Drugg (*op. cit.*, pl. 6, figs. 10 & 11), who also figured two specimens from the Callovian (*Peltoceras athleta* Zone), but in view of the large stratigraphical gap between the Pliensbachian/Bajocian interval and the Callovian these specimens were probably reworked. To summarise, *Nannoceratopsis triceras* ranges from the Pliensbachian to lowermost Bajocian in north-western Europe.

Sentusidinium sp. was found very rarely in the Harford Sands only (sample 5 Unit 6, see text-figure 2). The large and varied plexus of forms referable to *Sentusidinium* Sarjeant and Stover 1978 includes biostratiographically useful species. However, comparable forms to *Sentisidinium* sp. have been observed throughout the Jurassic, so it does not appear to be of great biostratigraphical value.



Text-fig. 5 The rock units yielding *Nannoceratopsis ambonis* in England (partly adapted from Cope *et al.* 1980).

Species Lists

Miospores

Spores

Acanthotriletes cf. *midwayensis* Pocock 1970
Auritulinasporites intrastriatus Nilsson 1958
Auritulinasporites scanicus Nilsson 1958
Calamospora mesozoica Couper 1958 (Pl.17, fig. 7)
Concavissimisporites verrucosus Delcourt & Sprumont 1955 amended Delcourt *et al.* 1963 (Pl.17, fig. 4)
Coronatispora valdensis (Couper 1958) Dettmann 1963
Cyathidites australis Couper 1953 (Pl.17, fig. 1)
Cyathidites concavus (Bolkhovitina 1953) Dettman 1963
Cyathidites minor Couper 1953 (Pl.17, fig. 3)
Cyathidites punctatus (Delcourt & Sprumont 1955) Delcourt *et al.* 1963
Dictyophyllidites crassexinus (Nilsson 1958) Tralau 1968 (Pl.17, fig. 6)
Dictyophyllidites harrissii Couper 1958 (Pl.17, fig. 2)
Duplexisporites problematicus (Couper 1958) Playford & Dettmann 1963
Foveotriletes subtriangularis Brenner 1963
Gleicheniidites senonicus Ross 1949
Ischyosporites variegatus (Couper 1958) Schulz 1967
Leptolepidites bossus (Couper 1958) Schulz 1967
Leptolepidites major Couper 1958
Leptolepidites rotundus Tralau 1968
Lycopodiacidites cerniidites (Ross 1949) Brenner 1963 (Pl.17, fig. 5)

Lycopodiumsporites austroclavatidites (Cookson 1953) Potonié 1956
Lycopodiumsporites clavatoides Couper 1958
Lycopodiumsporites semimuris (Danzé-Corsin & Laveine 1963) Resier & Williams 1969
Obtusisporis cf. *canadensis* Pocock 1970
Obtusisporis convexus Pocock 1970
Obtusisporis juncta (Kara-Murza 1956) Pocock 1970
Osmundacidites wellmanii Couper 1958
Todisporites major Couper 1958
Todisporites minor Couper 1958

Pollen

Alisporites thomasii (Couper 1958) Pocock 1962
Araucariacites australis Cookson 1947
Callialasporites dampieri (Balme 1957) Sukh Dev 1961
Callialasporites microvelatus Schulz 1966
Callialasporites minus (Tralau 1968) Guy 1971
Callialasporites trilobatus (Balme 1957) Sukh Dev 1961
Callialasporites turbatus (Balme 1957) Schultz 1967 (Pl.17, fig. 10)
Cerebropollenites mesozoicus (Couper 1958) Nilsson 1958 (Pl.17, fig. 11)
Classopollis classoides (Pflug 1953) Pocock & Jansonius 1961
Cycadopites carpentieri (Delcourt & Sprumont 1955) Singh 1964 (Pl.17, fig. 12)
Cycadopites minimus (Cookson 1947) Pocock 1970
Cycadopites nitidus (Balme 1957) Pocock 1970
Perinopollenites elatoides Couper 1958 (Pl.17, fig. 8)
Podocarpidites ellipticus Cookson 1947
Podocarpidites multesimus (Bolkhovitina 1956) Pocock 1962
Spheripollenites psilatus Couper 1958
Spheripollenites scabratus Couper 1958 (Pl.17, fig. 9)
Vitreisporites pallidus (Reissinger 1950) Nilsson 1950

Microplankton

Dinoflagellate cysts

Nannoceratopsis ambonis Drugg 1978 (Pl.18, figs. 4 & 5)
Nannoceratopsis gracilis Alberti 1961 (Pl.18, fig. 1)
Nannoceratopsis spiculata Stover 1966 (Pl.18, fig. 2)
Nannoceratopsis triceras Drugg 1978 (Pl.18, fig. 3)
Sentusidinium sp. (Pl.18, fig. 6)

Acritarchs

Micrhystridium fragile Deflandre 1947 (Pl.18, fig. 9)
Micrhystridium lymensis Wall 1965 var. *gliscum* Wall 1965 (Pl.18, fig. 11)
Micrhystridium rarispinum Sarjeant 1960
Micrhystridium recurvatum Valensi 1953 (Pl.18, fig. 10)
Micrhystridium stellatum Deflandre 1942 (Pl.18, fig. 12)
Veryhachium sp.
Caddasphaera halosa (Filatoff 1975) Fenton, Neves & Piel 1980 (Pl.18, fig. 8)
Leiosphaeridia sp.

Miscellaneous

Prasinophyceae; *Tasmanites newtoni* Wall 1965 (Pl.18, fig. 7)

Sarcodina; Foraminiferal test-linings.

Acknowledgements

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Explanation of Plates 17 and 18

Plate 17

Miospores and pollen from Jackdaw Quarry
(for detailed explanation see text).

Plate 18

Microplankton from Jackdaw Quarry
(for detailed explanation see text).

Plate 17

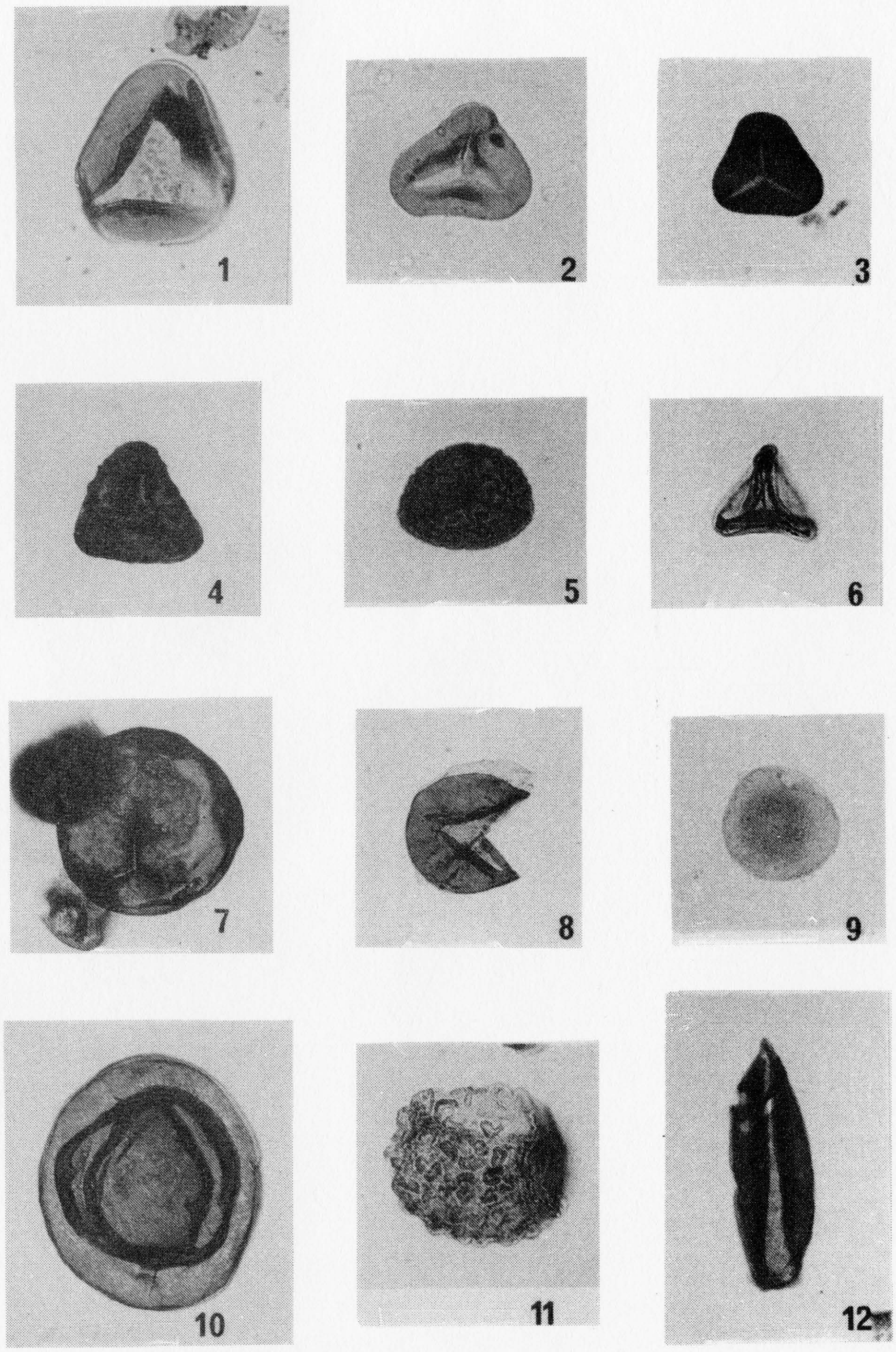
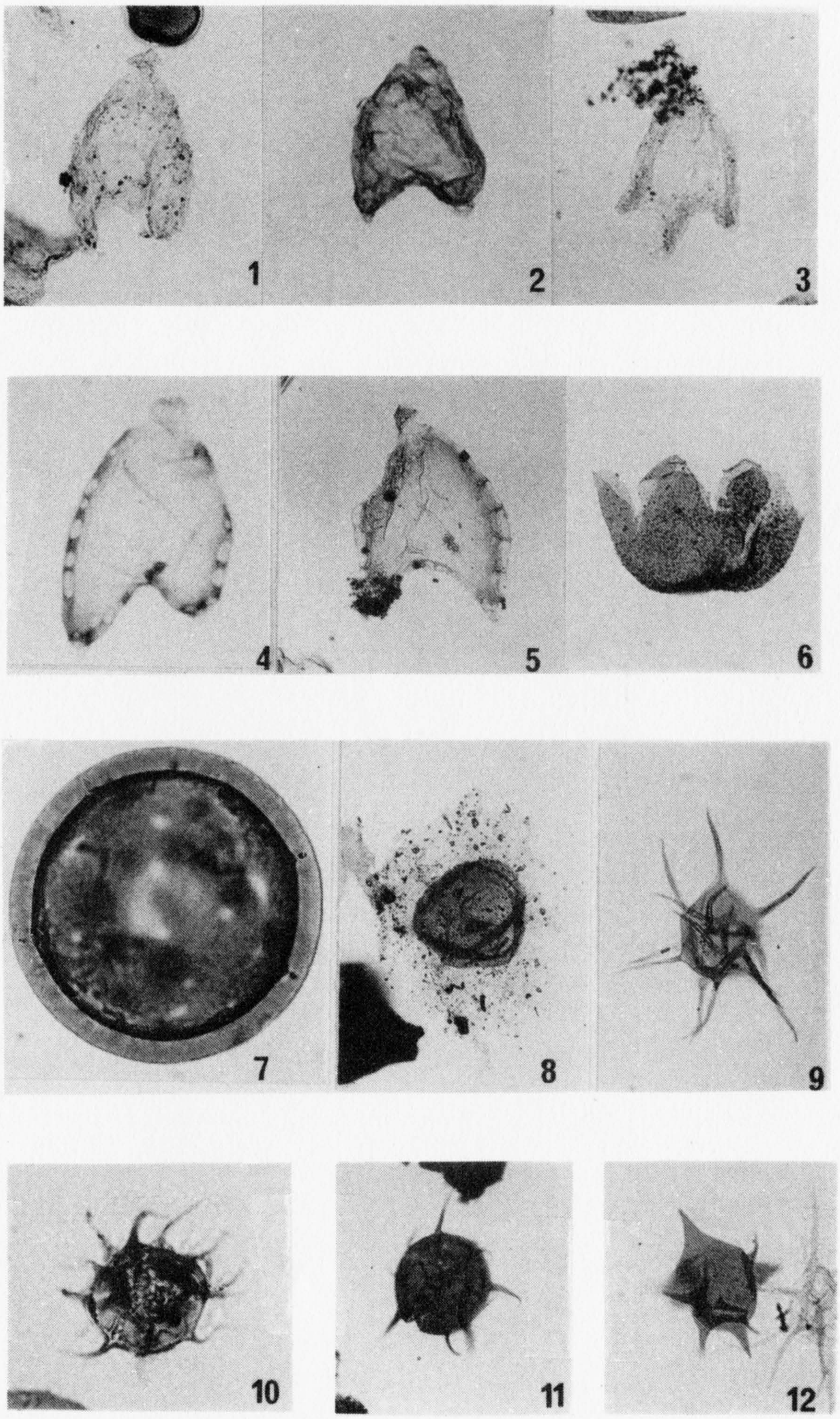


Plate 18



Erratum

'The palynology of the Aalenian (Middle Jurassic) sediments of Jackdaw Quarry, Gloucestershire England' by J. B. Riding was published in *Mercian Geologist*, vol. 9, no. 2, 111-120, 1983.

The published 'Explanation of plates 17 and 18' (p. 120) is unfortunately inadequate and a full explanation is printed below. The Editor apologises for any misunderstanding arising from this error.

Explanation of plates 17 and 18

Each figured specimen is followed by its slide number and 'England Finder' co-ordinate.

The slide number is prefixed by the sample number (see text-fig. 2).

The material is housed in the Department of Geology, University of Sheffield.

Plate 17

1.	*Cyathidites australis* Couper 1953	3, J5/5, H46/4.
2.	*Dictyophyllidites harrisii* Couper 1958	4, J6/4, N43.
3.	*Cyathidites minor* Couper 1953	4, J6/S11, Q41/1.
4.	*Concavissimisporites verrucosus* Delcourt & Sprumount 1955 emended Delcourt, Dettman & Hughes 1963	2, J3/S13, Q29.
5.	*Lycopodiacidites cerniidites* (Ross 1949) Brenner 1963	2, J4/S12, H33/4.
6.	*Dictyophyllidites crassexinus* (Nilsson 1958) Tralau 1968	3, J5/S12, F44.
7.	*Calamospora mesozoica* Couper 1958	7, J9/DS10, H24.
8.	*Perinopollenites elatoides* Couper 1958	5, J7/S11, L32/1.
9.	*Spheripollenites scabratus* Couper 1958	7, J9/D5, N27/1.
10.	*Callialasporites turbatus* (Balme 1957) Schulz 1967	5, J7/S12, M22/1.
11.	*Cerebropollenites mesozoicus* (Couper 1958) Nilsson 1958	3, J5/S12, G34/3.
12.	*Cycadopites carpentieri* (Delcourt & Sprumont 1955) Singh 1964	2, J4/S12, H31/3.

Magnification, all figures, $\times 500$

Plate 18

1.	*Nannoceratopsis gracilis* Alberti 1961	10, J12/7, M49/3.
2.	*Nannoceratopsis spiculata* Stover 1966	7, J9/S14, K35.
3.	*Nannoceratopsis triceras* Drugg 1978	10, J12/7, T44.
4.	*Nannoceratopsis ambonis* Drugg 1978	10, J12/3, Q31.
5.	*Nannoceratopsis ambonis* Drugg 1978	7, J9/S13, P55.
6.	*Sentusidinium* sp.	5, J7/S11, E32.
7.	*Tasmanites newtoni* Wall 1956	7, J9/S14, U23/1.
8.	*Caddasphaera halosa* (Filatoff 1975) Fenton, Neves & Piel 1980	7, J9/S12, M47.
9.	*Micrhystridium fragile* Deflandre 1947	7, J9/S11, 040/1.
10.	*Micrhystridium recurvatum* Valensi 1953	9, J11/S12, K46/3.
11.	*Micrhystridium lymensis* Wall 1965 var. *gliscum* Wall 1965	8, J10/1, Q35.
12.	*Micrhystridium stellatum* Deflandre 1942	7, J9/S12, M47/4.

Magnification, figures 1–8, $\times 500$.
figures 9–12, $\times 750$.